

Influence of irrigation recharge on groundwater nitrate-N on the Greenfields Bench, MT

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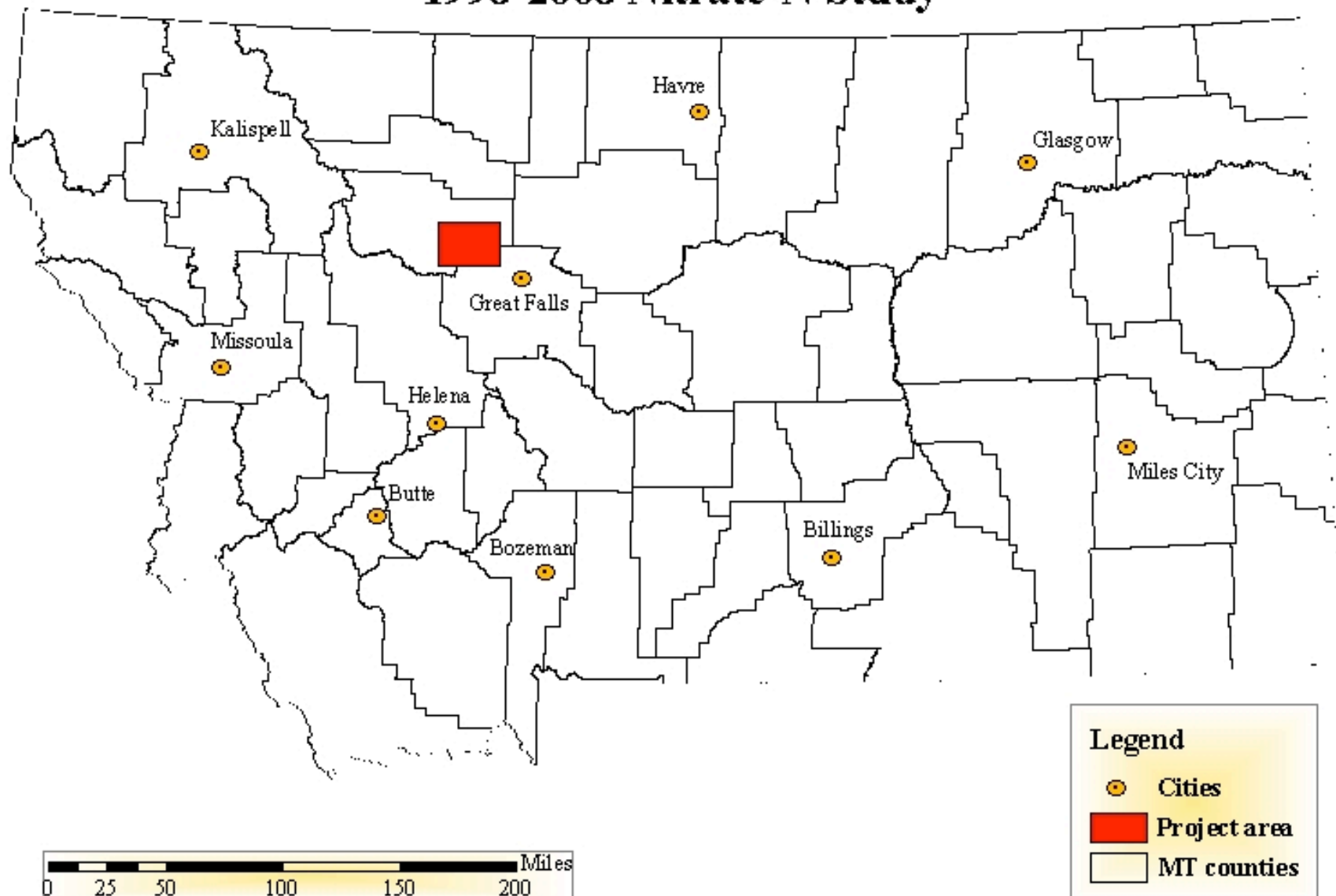
Montana Department of Agriculture

Ground Water Protection Program

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Greenfields Bench

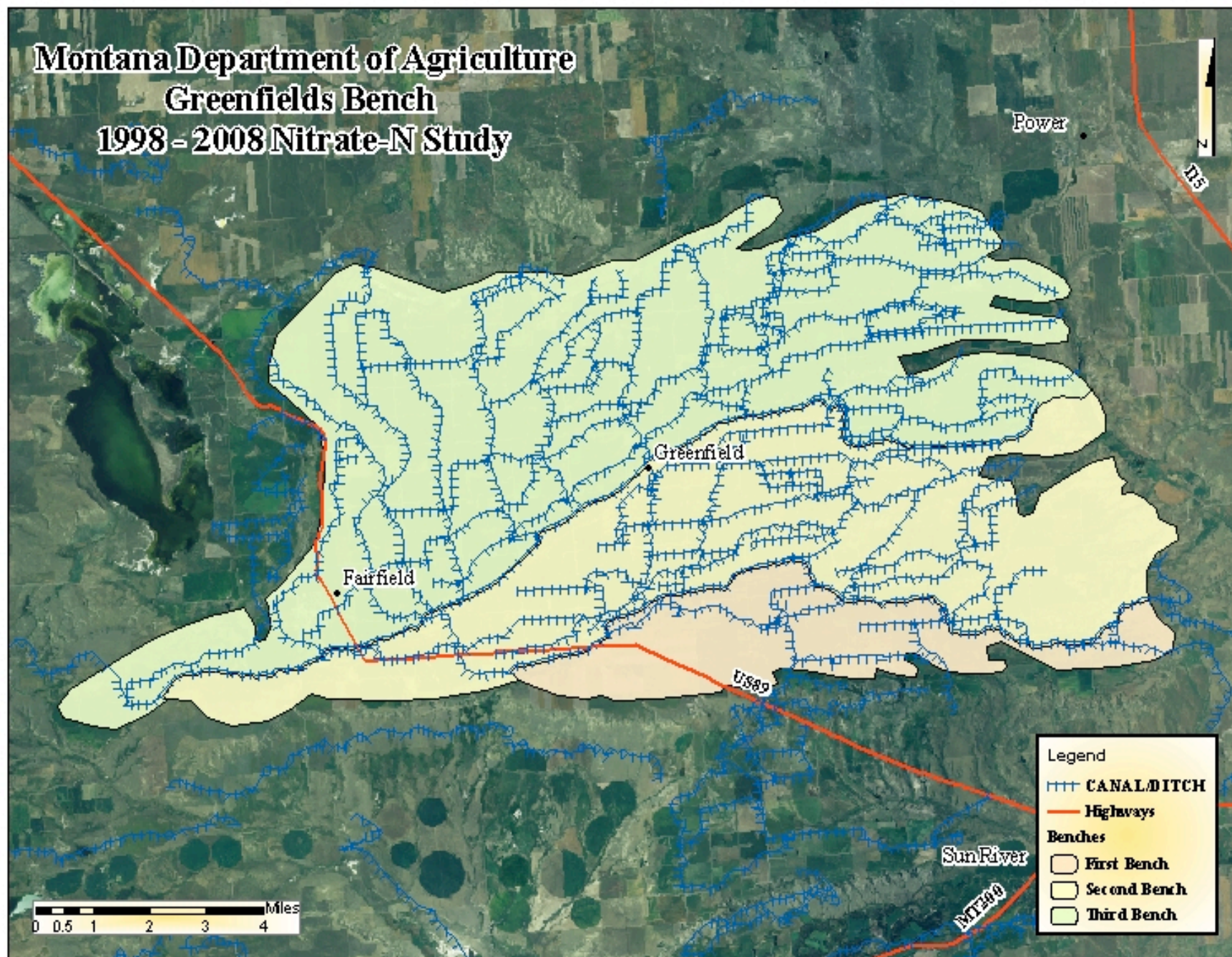
1998-2008 Nitrate-N Study



Greenfields Bench

- Greenfields Irrigation District supplies water to ~83,000 acres
- District fed by 3 reservoirs
 - Gibson Reservoir – 99,100 ac. ft. storage
 - Pishkun Reservoir – 46,700 ac. ft. storage
 - Willow Creek Reservoir – 32,400 ac. ft. storage
- 295 miles of canals and laterals
- Known for production of malt barley

**Montana Department of Agriculture
Greenfields Bench
1998 - 2008 Nitrate-N Study**



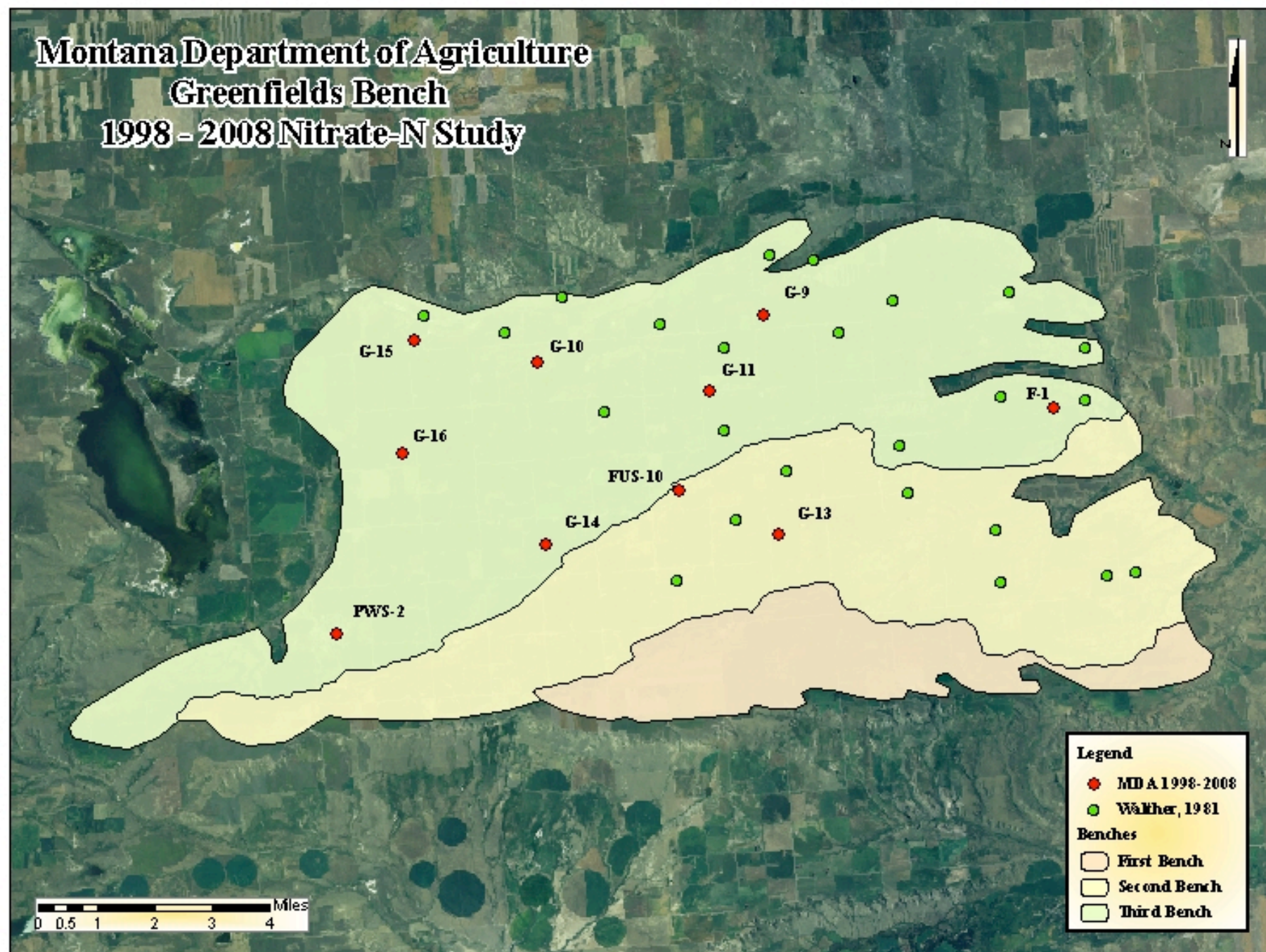
Hydrogeology

- Topographically isolated bench of Cretaceous age
- Overlain by quaternary gravel deposits (1 to 12 m thick)
- Benches formed by down cutting and terrace gravel deposition of the Sun River (pre- and early Wisconsin Eras)
- Somewhat excessively drained clay loam soils (~ 20 cm thick) overlay poorly sorted sand and gravels in a clay matrix (Miller, 2005)
- Shallow aquifer recharged by irrigation/precipitation – direct hydraulic connection
 - 70% of recharge from irrigation, canal leakage, and ponded tailwater (Osborne et al., 1983)
 - During irrigation season (May-July) groundwater levels may rise to the ground surface

Data

- 10 groundwater wells with minimum of 5 years collection (mean=8.8 years) between 1998-2008 ($n=171$)
 - Growing season data (April – September)
- Climate data from Greenfields weather station (COOP ID: 242857)
- Comparison with dataset of earlier nitrate-N study on the Bench ($n=261$) (Walther, 1981)

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Greenfields Bench
1998 - 2008 Nitrate-N Study



Dataset comparison

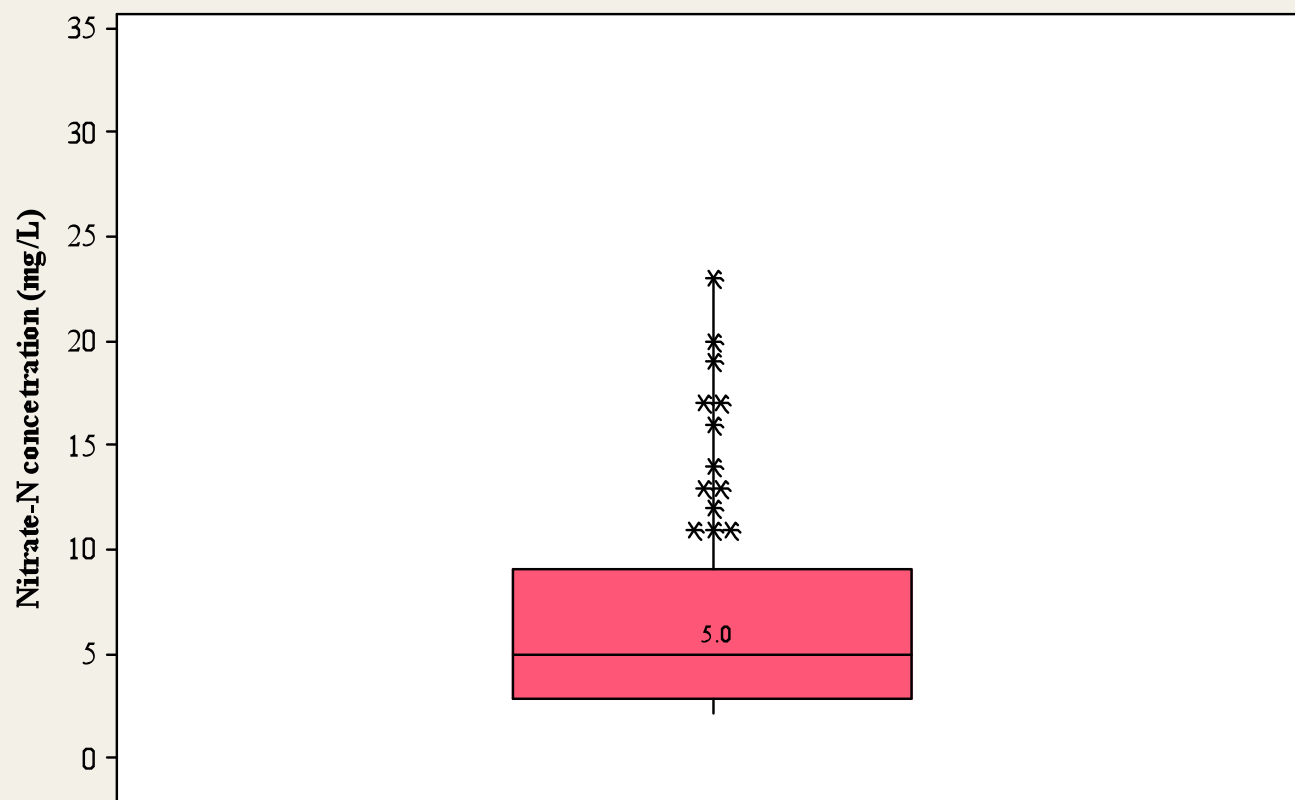
Table 1. Well characteristics of all wells on the Greenfields Bench and for two datasets

Well characteristics	Greenfields Bench	MDA 1998-2008	Walther 1981
Count	679	10	18
Minimum (ft.)	0.0	14.8	14.0
Maximum (ft.)	285.0	63.0	120.0
Mean (ft.)	28.0	29.1	26.5
Median (ft.)	22.0	25.0	20.0
Std. deviation (ft.)	28.0	14.2	24.1
Con. Level (95%)	2.1	10.2	11.9

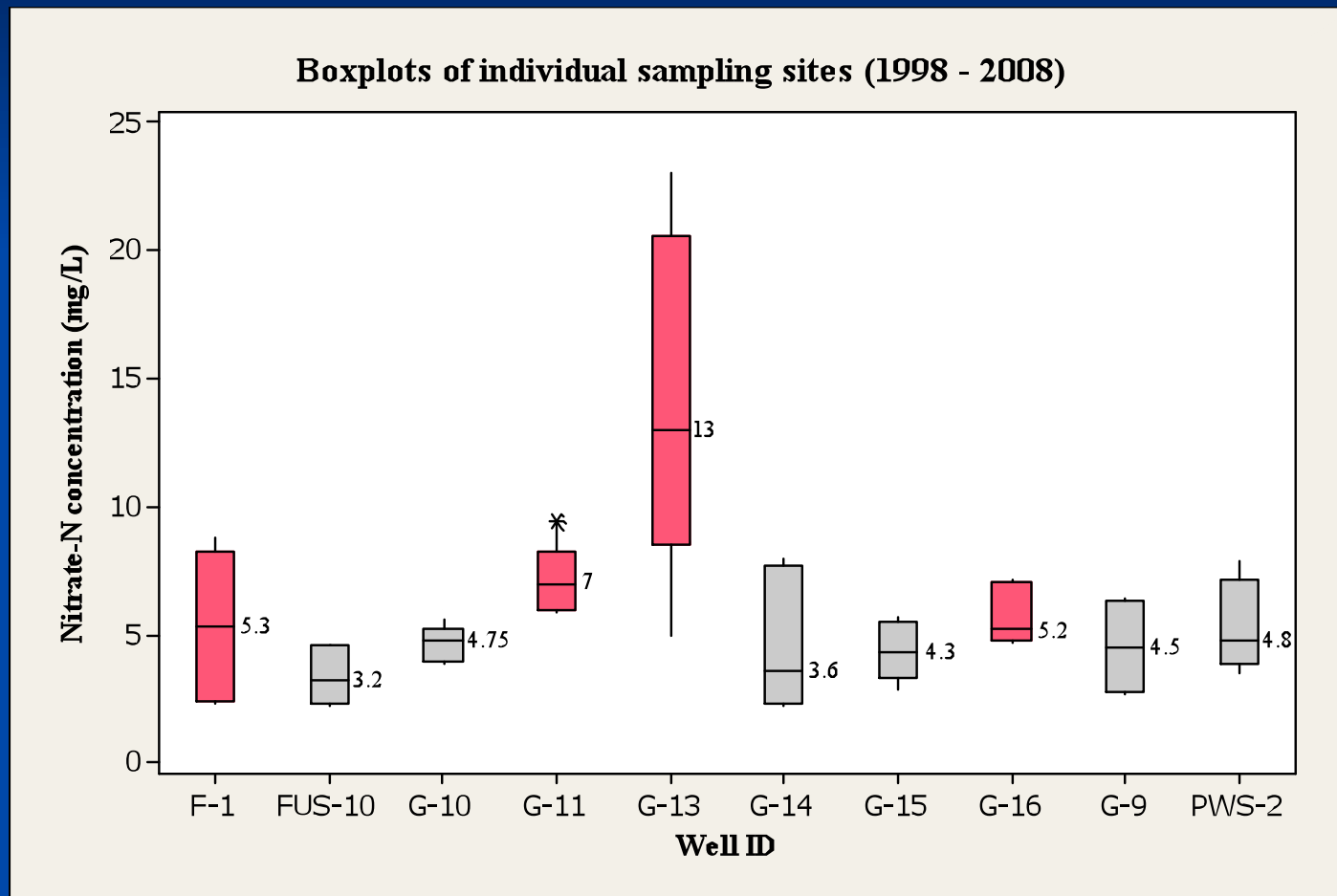
- Population means not significantly different ($\alpha = 0.05$) among three datasets for total well depth
- MDA and Walther datasets representative of GWIC database for the Bench

MDA 1998-2008

Boxplot for all wells sampled by MDA for the Greenfields Bench (1998 - 2008)

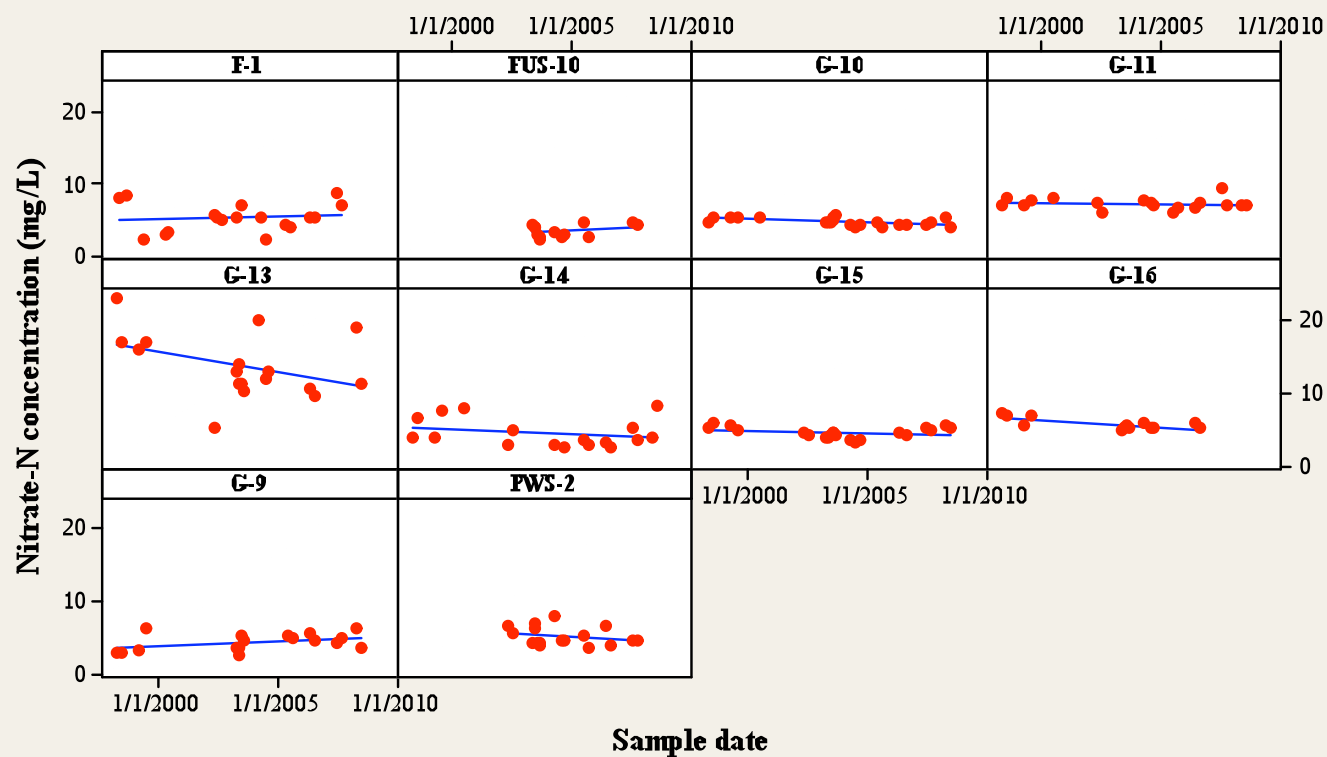


MDA 1998-2008

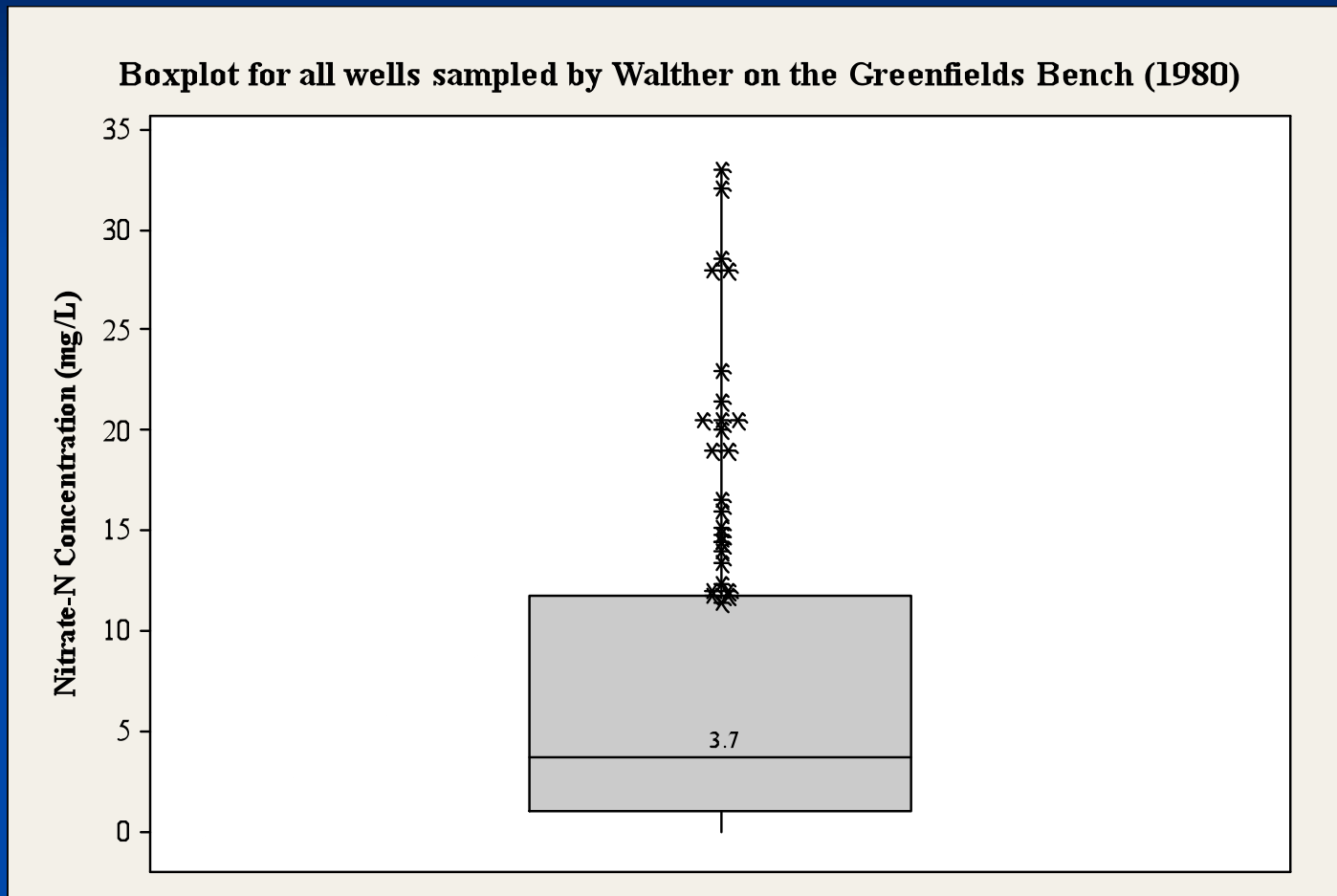


MDA 1998-2008

Trend analysis of nitrate-N concentration over time



Walther, 1981

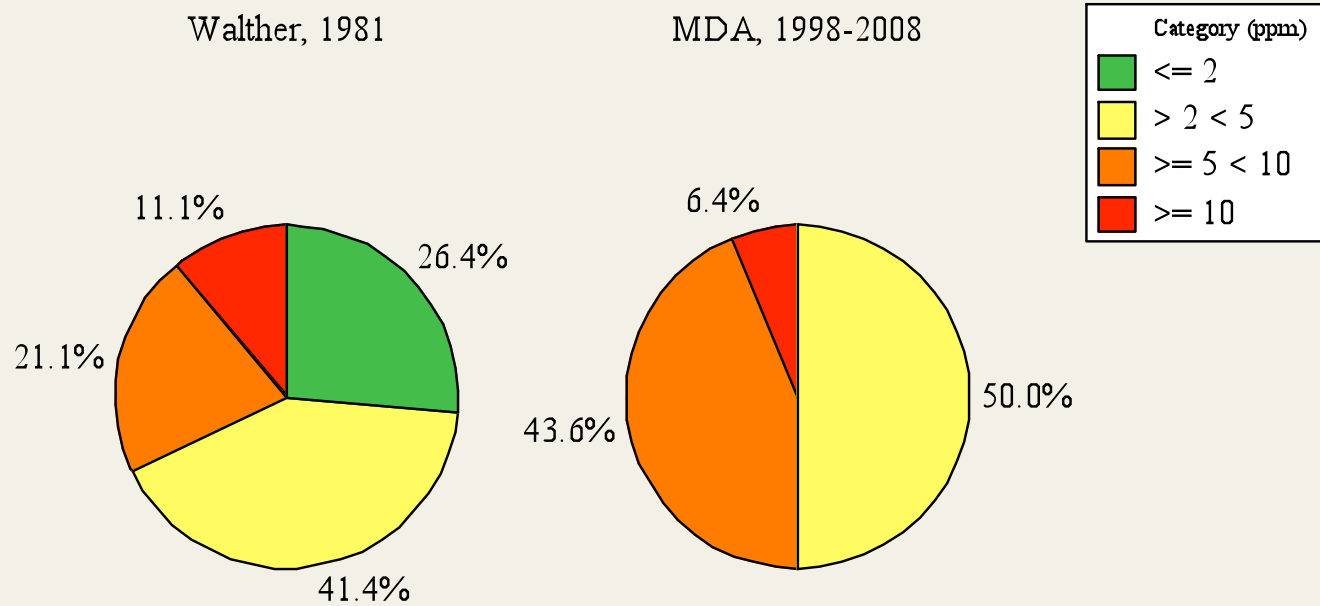


Dataset comparison

- Mean nitrate-N concentrations were not significantly different ($\alpha = 0.05$) between MDA and Walther, 1981 datasets (P-value = 0.107)
- Median nitrate-N concentration greater over 1998-2008 versus 1980 field season
- Significant correlation between nitrate-N concentrations and static water level not observed in either study
 - 1998-2008; P-value = 0.073; PCC = -0.168
 - Shallow groundwater, greater likelihood of elevated nitrate concentrations

Dataset comparison

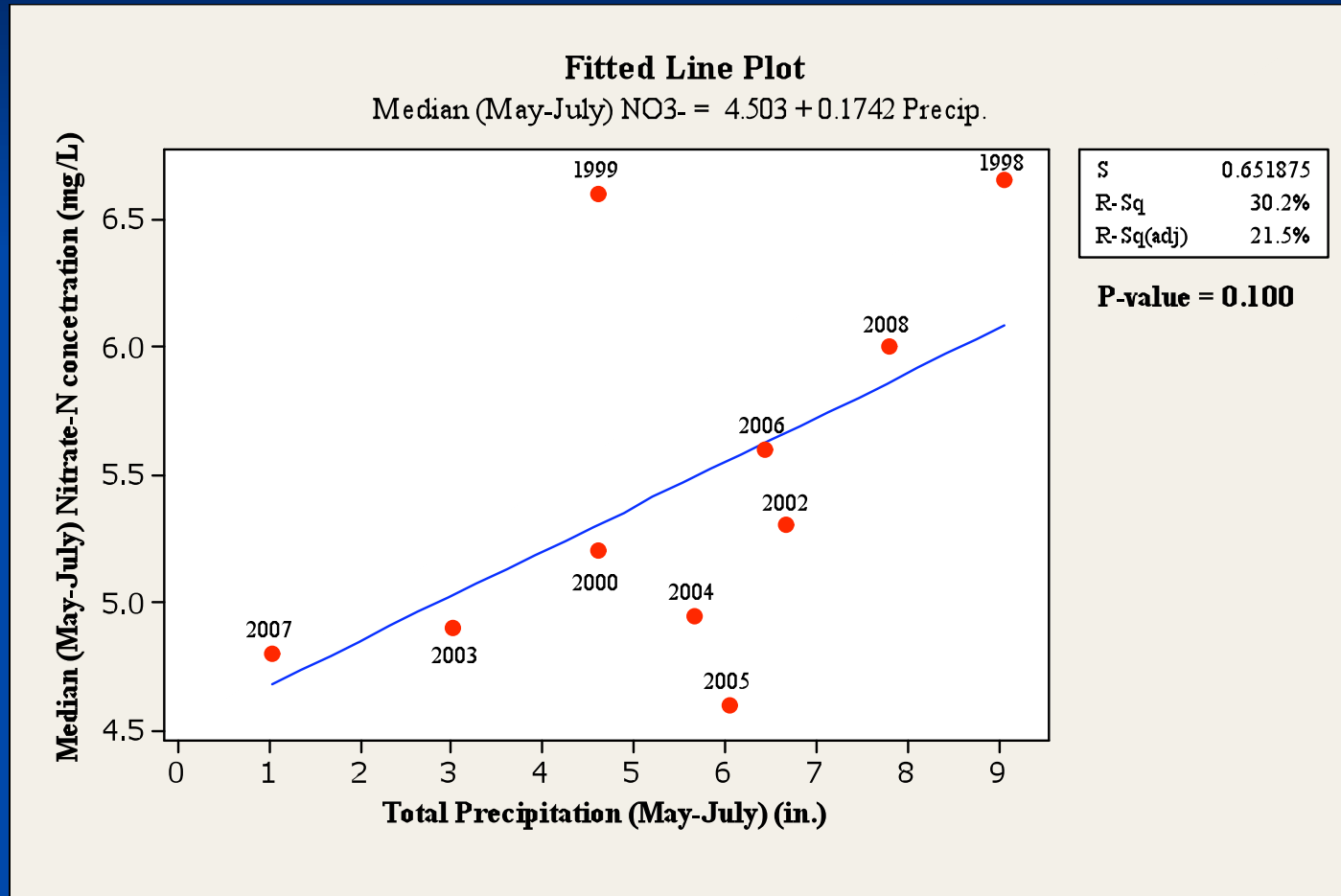
Distribution of nitrate-N concentrations



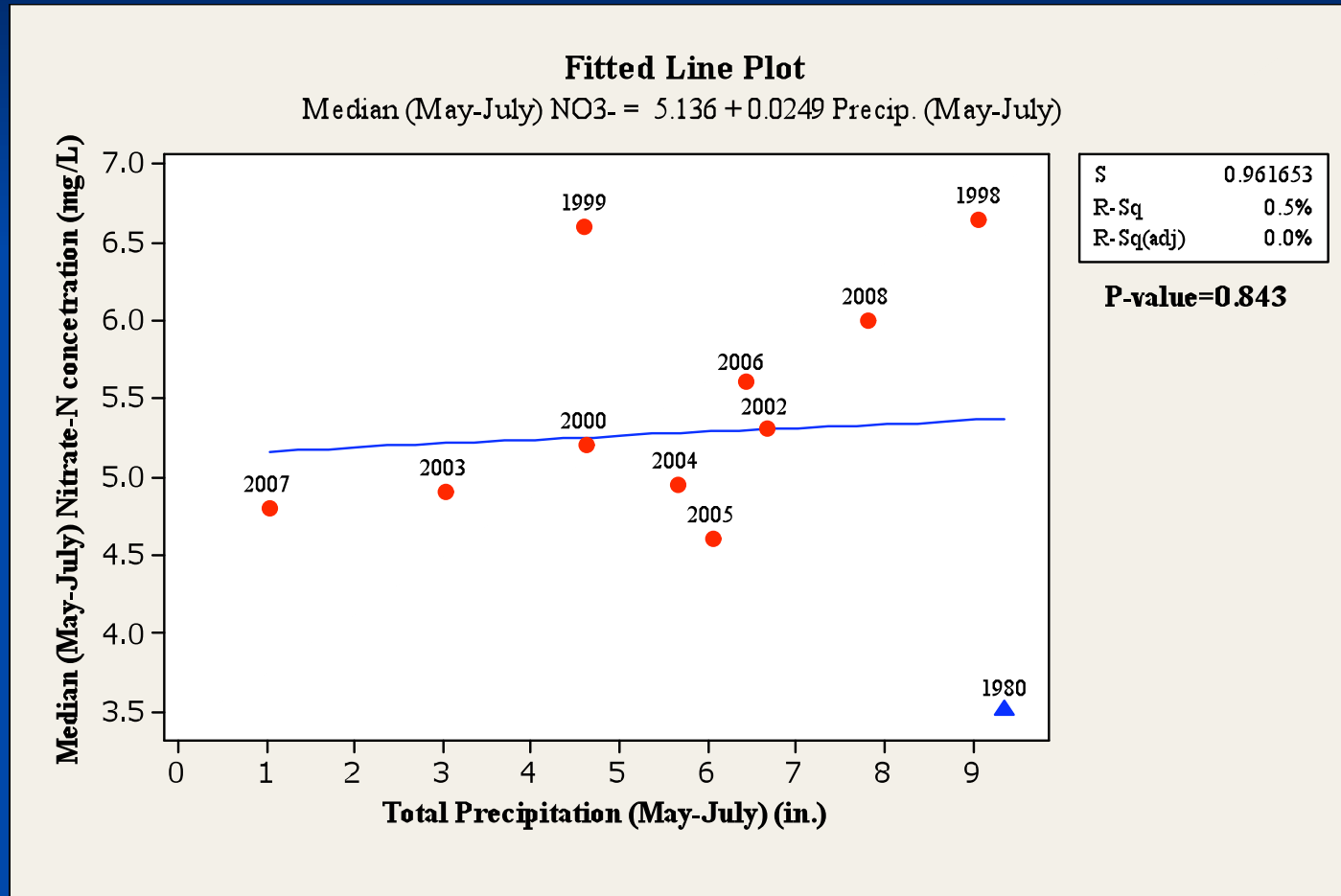
Irrigation Recharge Rate

- 1980 – 90% flood irrigation, 10% sprinkler (Walther, 1981)
- 2002 – 55-60% flood irrigation, 40-45% sprinkler (wheel-line; center pivot) (Miller et al., 2002)
 - Sprinkler-use increasing in grains vs. alfalfa/hay
- Irrigation efficiency study (Miller, 2005)
 - Wheel-line: 9 cm of recharge (70% < flood)
 - Center pivot: 3 cm of recharge (90% < flood)

Regression analysis



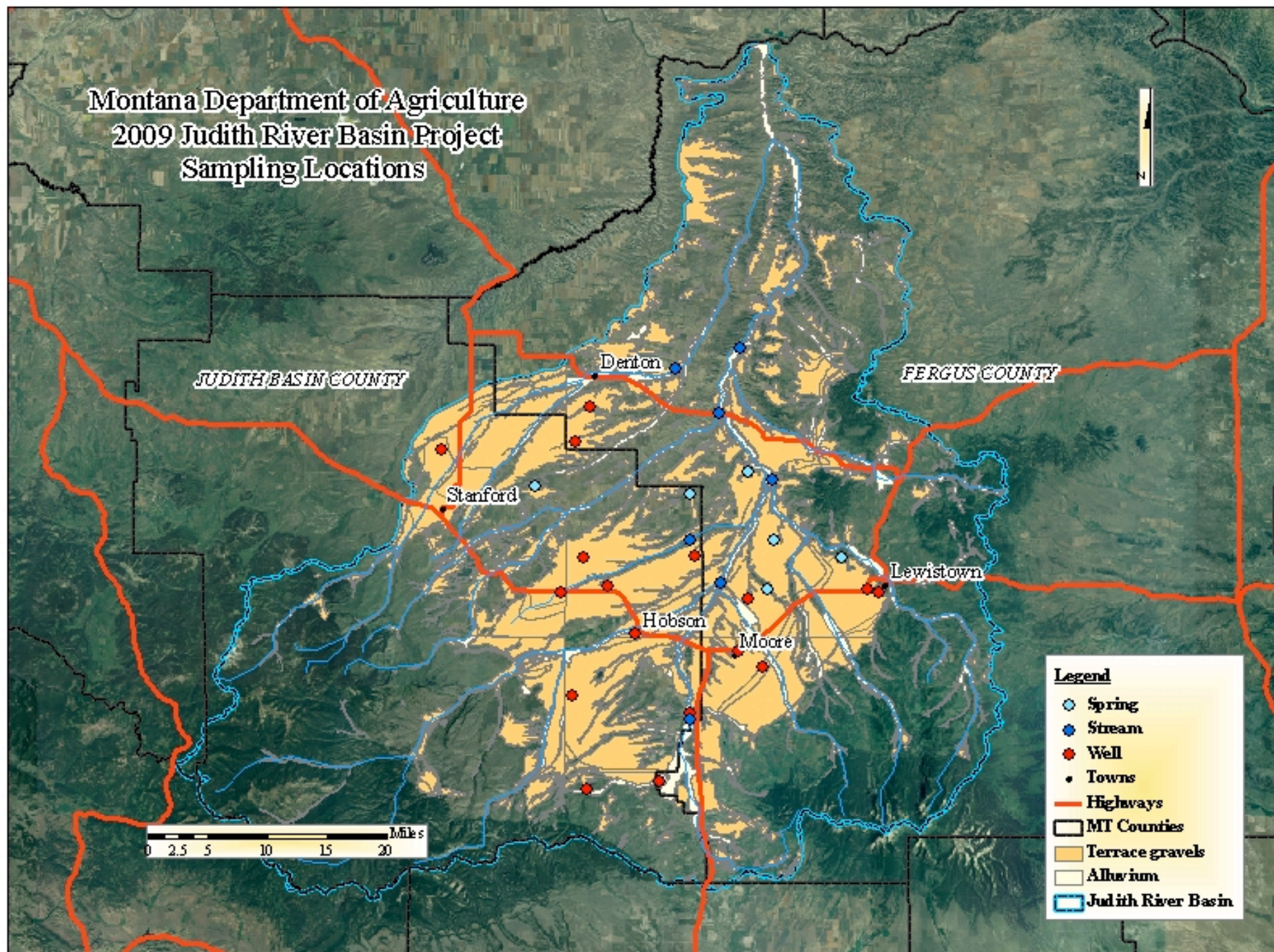
Regression analysis



Greenfields vs. Judith River Basin

- Hydrogeology of both areas is very similar
 - Aquifer storage
 - Hydraulic conductivity (under natural conditions)
 - Soil texture, depth and genesis
- Agriculture
 - Greenfields Bench– irrigated small grains (>>barley)
 - Judith River Basin – dryland small grains (>>wheat)

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2009 Judith River Basin Project
Sampling Locations



Greenfields vs. Judith River Basin

■ Judith Basin

- 199 detections of 33 pesticide analytes in groundwater in 2009
- Rural wells completed in terrace gravels had a median nitrate-N concentration of 19.50 mg/L and mean of 5.46 detects/sample ($\sigma = 2.08$) ($n=17$ sites)
- Greenfields Bench: median 5.0 mg/L and 8.83 detects/sample ($\sigma = 2.68$) ($n=10$ sites)

■ Dryland cropping systems exhibit lower herbicide loading but higher nitrate concentrations

$\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ isotopes

- Greenfields Bench (1998)
 - N predominantly nitrate and ammonium fertilizer; possibly SON ($n=16$)
- Judith River Basin (2009)
 - N is SON; some mixed signatures with manure/septic effluent ($n=12$)

Unintended consequences

- Increases in irrigation efficiency may lead to a...
 - Decrease in water quality
 - Decrease in storage
 - Shrinking of wetland and riparian habitat extent where induced recharge from irrigation feeds these systems
- Where is the 'break-even' point?
 - Point where efficiency gains result in impaired groundwater quality and/or reduced wetland/riparian habitat?

Bibliography

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Questions?

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